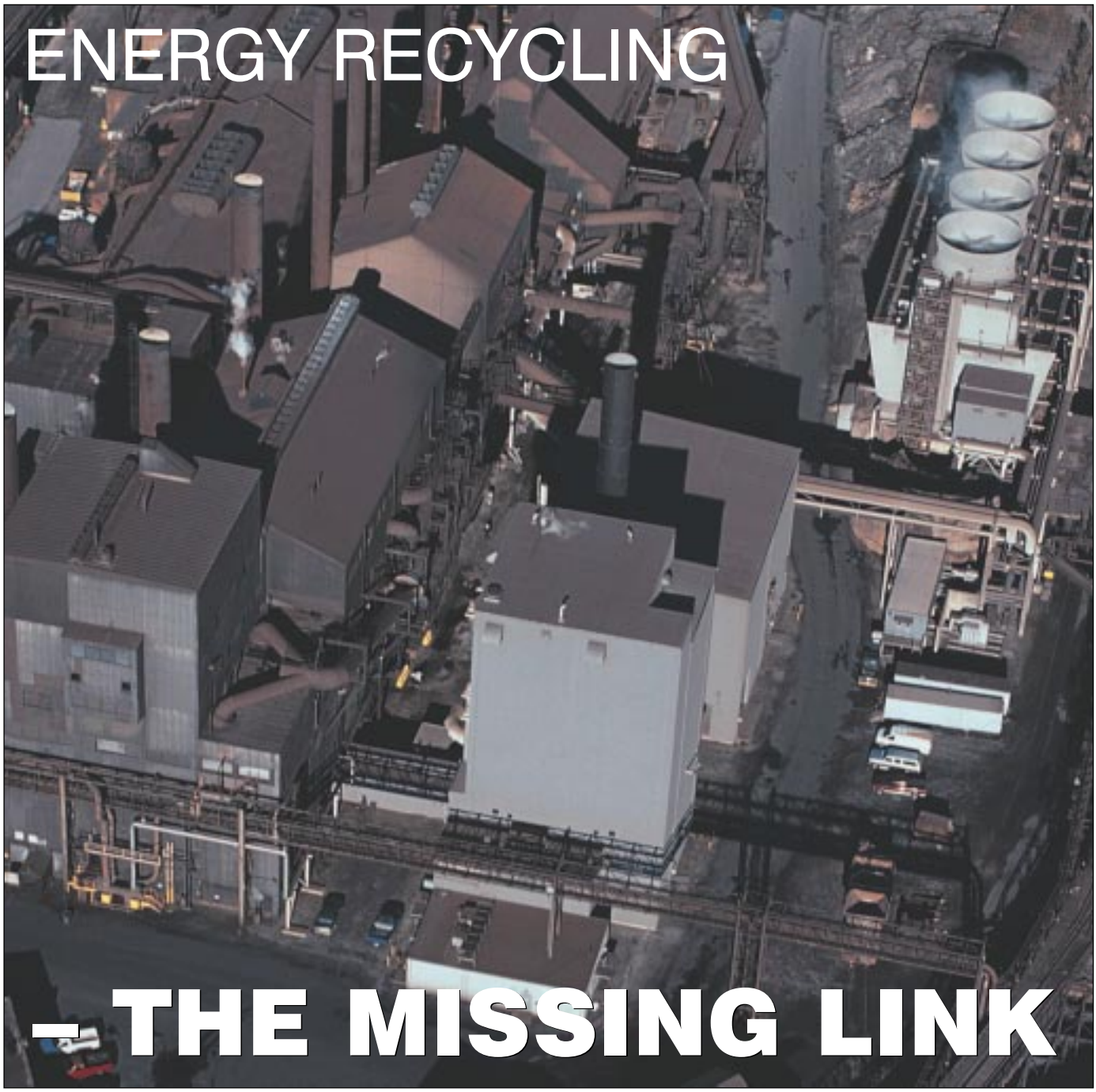
Beating the blackouts

Spencer Abraham speaks out

ENERGY RECYCLING – THE MISSING LINK



by Thomas R Casten

The US faces severe energy related problems, including over-taxed transmission, high natural gas prices, regions with air quality problems, and concerns about greenhouse gas emissions. The economy is increasingly vulnerable to OPEC, extreme weather and terrorists, and power quality – appropriate for the last century's electric motors – is inadequate for today's digital economy. An Electric Power Research Institute (EPRI) study, carried out before the 14 August 2003 blackout, put the cost of power quality problems to the US economy at US$119 billion per year.[1] US industry is understandably concerned.

CURRENTLY PROPOSED SOLUTIONS

EPRI says it will cost US$226 billion to shore up the electrical transmission system. Faced with dwindling low-cost gas fields in the continental US, the gas industry proposes more drilling in Alaska, with long pipes to the US and LNG terminals to handle expensive gas imports. State and federal environmental agencies, seeking cleaner air, mandate expensive scrubbers for the nation's aging fleet of central generation plants. President Bush refuses to set limits on greenhouse gas emissions, claiming this will cause economic disruption. However, these conventional approaches all start with the same flawed world view – that central generation of electricity is optimal. Instead of improving electric generation efficiency, each group urges government to throw money at the problem, raising energy prices and causing further loss of industrial jobs. We need better solutions.

Energy recycling is the missing link – a fresh approach that addresses all energy related problems while saving money, reducing pollution, reducing vulnerability, and providing new jobs by creating new revenue streams to basic industry for sale of their waste energy. And government can induce energy recycling with no cost to the taxpayer by simply modernizing regulations and removing current barriers to efficiency.

ENERGY RECYCLING BASICS

Manufacturers of most products, including electricity, vent significant byproduct energy. Much of this waste can be economically recycled into electricity and useful thermal energy. Recycled energy adds no pollution and displaces the pollution and cost from fossil fuel that would have been burned to produce the same energy. Average US central generation of electricity, which accounts for over 90 percent of US power, is needlessly inefficient and dirty, precisely because remote plants cannot recycle

byproduct waste heat. Average US central generation delivers end users one unit of energy for every three units of input fuel; this miserable 33 percent efficiency has not improved in 43 years. The collective energy thrown away by US central electric generation plants could displace nearly half of the nation's boiler fuel, but it is uneconomic to transport heat over long distances. Each decision to build new, isolated central generation is a 25-40 year decision to waste energy.

The US electric industry wastes 20 quadrillion Btu's each year, equal to 20 percent of the nation's 100 quads of total energy use. Simply building new electric generation plants near thermal users would allow the plants to economically recycle at least half of this waste, cutting the nation's total fuel use by 10 percent. In spite of many barriers, US energy innovators have managed to build about 65,000 megawatts (eight percent of total generation) of decentralized plants that recycle waste heat. A recent study sought the best way to meet the expected US 43 percent electric load growth over the next two decades and compared serving the new load with decentralized or with central generation.[2] The conclusion: decentralized generation cuts power costs by 40 percent compared to central generation.

Decentralized CHP plants cost more per kilowatt of generating capacity than new central plants, a seeming disadvantage. But this comparison yields the wrong conclusion. Total capital cost for new central generation includes both

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Cokenergy at Ispat Inland Steel, East Chicago, Indiana
Note: City of Chicago across Lake Michigan

the generating plant and new T&D investments. Centrally generated power must be transformed to higher voltages, must travel through long, leaky wires and then be transformed back to user voltages. This process 'eats' one kilowatt hour in 10. Since only 90 percent of centrally generated power reaches end users, society must build 1.1 megawatts of central generation and 1.1 megawatts of new T&D for each megawatt of load. An alternative is to simply build one megawatt of distributed generation at the load. The study referenced above found that decentralized generation would avoid nearly US$400 billion of capital investment over the next 20 years, reducing needed capital investment from US$900 billion to US$500 billion.

Decentralized generation, by recycling waste energy and avoiding line losses, dramatically reduces air pollution versus central plants. Emissions of NOx, SO_2 and particulate matter (PM10) are respectively 58 percent, 68 percent and 43 percent lower in the decentralized generation scenario than in the central generation scenario. Carbon dioxide emissions dropped by 49 percent with decentralized power. Recycling energy is the missing link.

RECYCLING INDUSTRIAL WASTE ENERGY

A second option is to recycle industrial waste heat, waste fuel, and pressure drop into heat and power. Visit a steel mill, refinery, chemical or glass factory on a cold day and you will see vast clouds of vapor – wasted energy. EPA gas flare data identifies roughly 88,000MWh of wasted energy every hour. Recycling this waste could power 22,000MW of electric generation, the equivalent of 22 nuclear plants. Produce combined heat and power with flare gas to net 66,000MW of heat and power. We estimate that 10,000MW could be produced without any new fuel by extracting power from the steam and gas pressure drop found throughout industry and on university and medical campuses. Recycling hot exhaust might yield 10,000 to 50,000 more megawatts of useful energy.[3]

RECYCLED ENERGY IS CLEAN ENERGY

No incremental fossil fuel is burned and no incremental air pollution is


Lakeside


Northlake

produced when waste energy is recycled into heat and power. Consequently, recycled energy is every bit as environmentally friendly as heat and power from renewable energy sources, including solar energy, wind and biomass. Recycled energy should therefore qualify for every renewable energy incentive.

RECYCLED ENERGY CASE STUDIES

Building recycled energy projects has been incredibly difficult, because utilities typically oppose onsite generation, fearing loss of revenue and potential weakening of the 'electric monopoly' logic. But in 1994, NiSource, parent of Northern Public Service Company (NIPSCO), took a more enlightened view. NIPSCO's steel customers were in trouble. Legacy costs for retirees' health and pension, intense foreign competition, and aging production facilities had combined to slash steel industry profits and cash flow. There were, in every steel plant, huge waste energy flows that could be recycled to cut costs, but the steel industry had more urgent demands for capital in core production facilities.

NiSource formed a subsidiary, Primary Energy, and invested US$300 million between 1994 and 2003 in six energy projects with capacity to recycle roughly 900MW of heat and power from steel plant waste heat and blast furnace gas. Myriad rules stood in the way, but Primary Energy persevered. Indiana law prohibits any third party from selling electricity to a host, so Primary Energy crafted tolling arrangements under which US Steel, International Steel Group (ISG) and Ispat Inland pay to convert their waste energy to heat and power, which they use. NIPSCO offered electricity buy/sell arrangements at fair prices instead of demanding predatory backup power charges. When steel company credit was insufficient to support financing, NiSource bet on its customers and guaranteed loans. Union steelworkers were hired by the steel companies to operate each project, with Primary Energy providing supervisory engineers.

All three steel companies are much healthier today and currently produce and sell every possible ton of steel. Recycled energy has played an important role in this economic turnaround. The steel companies are collectively saving US$100 million per year and have reduced emissions and improved their power reliability.

The six recycling projects eliminate 19,000 tons of NOx, 22,000 tons of SO_2 and seven million tons of carbon dioxide emissions per year and have won several environmental awards.

Three projects, one at each company, burn blast furnace gas to make high-pressure steam, which drives extraction/condensing steam turbine generators. The projects are capable of 50MW to 160MW of electric generation and supply most of the mill's requirements for process and heating steam.

A conventional GE gas turbine feeds US Steel's cold rolled tin plant. The gas turbine exhaust is recycled to produce high-pressure steam that drives a steam turbine. Then the remaining energy is recycled again to heat 1600 gallons per minute of softened water used to wash the steel. By recycling waste heat, the plant achieves 2.5 times the efficiency of average central generation and saves money.

Hot exhaust from 368 coke ovens is converted to high-pressure steam by 16 heat recovery steam generators to drive a 95-megawatt electricity generator and provide 300,000 to 600,000 pounds of process steam.


Portside

DG as % of total US generation.

	100% CG	100% DG	Savings	% change
Total capital cost (capacity + T&D) Billons of dollars	$904	$506	$397	44%
2020 incremental power cost Billions of dollars	$153	$92	$61	40%
2020 incremental power cost Cents/kWh	9.13	5.48	3.64	40%
Emissions from new load Thousand metric tones				
NO_x	288	122	166	58%
SO_2	250	80	170	68%
PM10	22	12	9	43%
Million metric tones CO_2	777	394	383	49%

Impact of generating 2020 load growth with central or decentralized generation

Thomas R Casten has spent 30 years developing decentralized heat and power as founding President and CEO of Trigen Energy Corporation and its predecessors from 1977 through 2000, founding Chairman and CEO of Private Power from 2001 to 2003, and currently as Chairman and CEO of Primary Energy, a company specializing in recycling energy.

Casten has served as President of the International District Energy Association and has received the Norman R. Taylor Award for distinguished achievement and contributions to the industry. He currently serves on the board of the American Council for an Energy-Efficient Economy, the Center for Inquiry, and the Fuel Cell Energy Board, and is the Chairman of the World Alliance for Decentralized Energy (WADE).

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Blast furnace stove exhaust contains significant amounts of energy, but it is not hot enough to be economically recycled as electricity. Instead, Primary Energy uses the heat to dry coal for injection into North America's largest blast furnace. This has enabled Ispat Inland to significantly reduce natural gas and coke usage.

There are myriad energy recycling opportunities in the kilowatt size range. Turbosteam of Turner Falls, Massachusetts, installed a 50kW backpressure turbine to recycle steam pressure drop at the Suffolk County Jail in Boston, Massachusetts. The jail purchases medium pressure steam from Trigen Boston's district steam system and historically deflated the steam to low pressure with a valve. Since the 1997 installation of a backpressure turbine generator, the jail has enjoyed free electricity. They purchase no added steam, but send cooler condensate to the sewer.

ARE US$20 BILLS LYING ON THE GROUND?

Economists assert that there are no US$20 bills lying on the ground in a free market. Under this theory, it will be impossible to repeat what Primary Energy has done, since recycling energy innovators must have already captured all of the economic opportunities to recycle waste energy. Policy makers who support massive expenditures to fix energy problems must believe that there are no options that reduce pollution and vulnerability and save money. We think they are wrong.

The electric market is anything but free, and obsolete regulations make it largely illegal and/or uneconomic for would-be energy recycling innovators to pick up the 'US$20 bills'. These barriers are artifacts of the history of the 120-year-old electric industry.

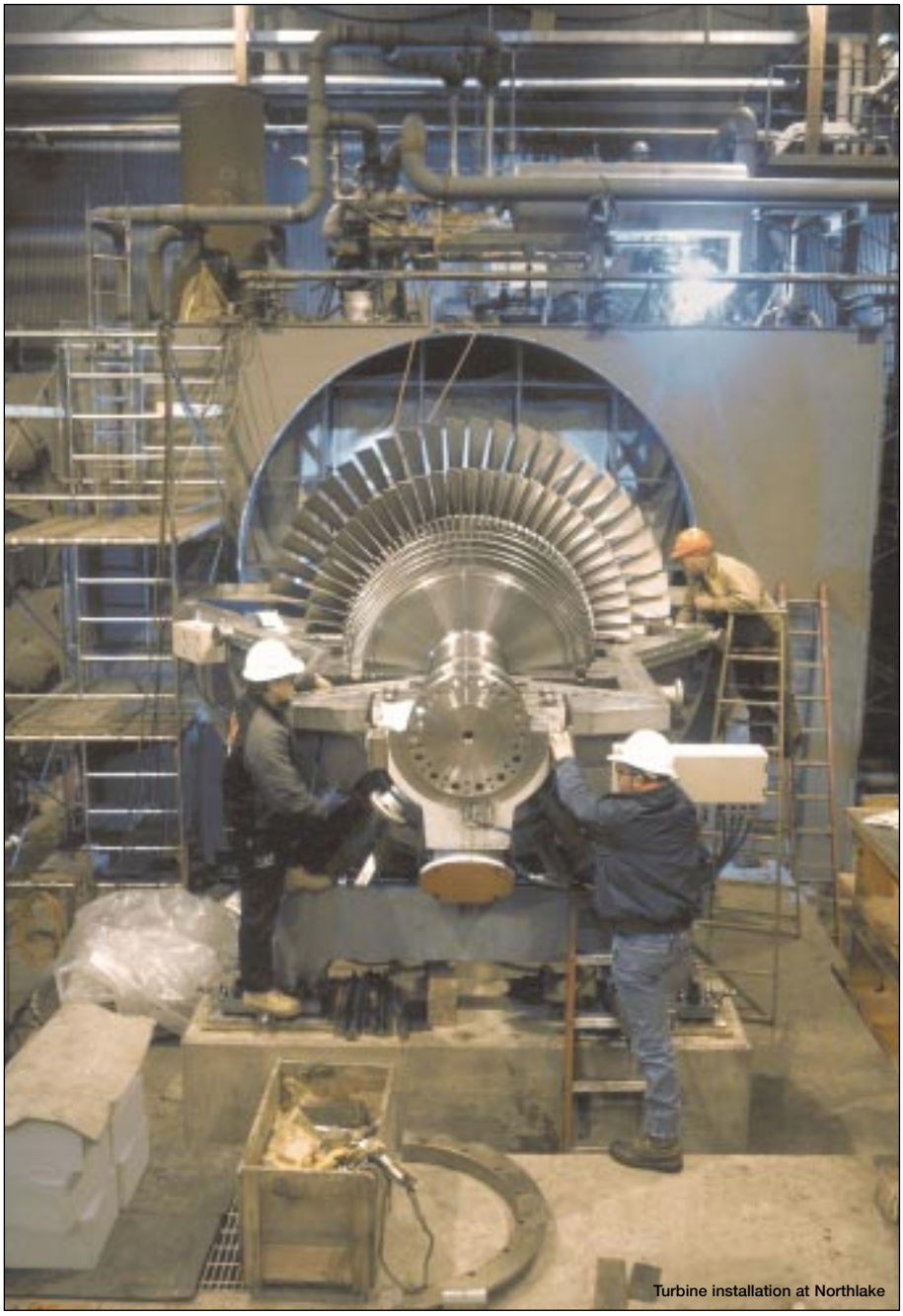
Electricity, arguably the most important invention of all time, became a commercial reality in 1880 in NYC and San Francisco. Word spread rapidly and every community wanted to electrify as quickly as possible. Early technology favored remote generation (hydroelectric plants and yesterday's coal plants) and there were, in the early days, substantial economies of scale. Assuming technology would always favor remote plants and that there would always be economies of scale in generation, governments all over the world decided to restrict competition and made Faustian bargains with electric entrepreneurs. In exchange for a monopoly in perpetuity, the entrepreneurs agreed to rapidly electrify each community. They were allowed fair returns on capital on the condition that they would pass all efficiency gains to the public in order to prevent excessive profits. This protected status lowered the cost of capital, making electricity more affordable. Everyone was expected to live happily ever after and, for years, real prices per kilowatt-hour declined.

For years, the industry worked hard to lower costs to lure customers away from self-generation, gas lighting and muscle power; and a world view grew that central generation is the optimal way to produce and deliver power.

But technology marched on, resulting in ever more reliable, efficient and cost-effective smaller generation plants. Add the advantages of energy recycling, avoidance of line losses, reduced vulnerability and improved power quality, and the conclusion is inescapable – decentralized generation wins.

Netherlands, Finland and Denmark each recognized the value of decentralized generation 20 years ago and each country now generates over 40

percent of their nation's power onsite with maximum energy recycling. These countries use 50 percent less fuel per kWh than the US and have consequently maintained robust industrial production. Portugal saw the light and now offers prices for power from decentralized plants that include avoided central plant fuel and capital, avoided T&D capital and line losses, and avoided pollution. India just reversed 50-year-old policies and now offers long-term contracts at over six cents per kWh for power made at sugar cane factories from bagasse.



Turbine installation at Northlake

The US, in spite of modest deregulation, remains unintentionally hostile to recycled energy. 15 states retain laws that ban the sale of electricity to anyone but the utility, even if the power is generated on the site of a user. All 50 states ban private wires that cross public roads, thus denying energy innovators any leverage in negotiating the prices their distribution monopoly charges for moving power across the street to the nearest retail customer. Public service commissions regularly approve backup charges that assume 100 percent failure at system peak of all decentralized generation. No commission currently gives DG any credit for avoided T&D capital, avoided line losses or avoided pollution. State and federal environmental rules require new generation to be up to 50 times less polluting than existing generation, while allowing old, inefficient central generation to emit at historic pollution levels. Commissions deny rewards to utilities for efficiency gains.

The bottom line is the US suffers from needlessly inefficient and dirty use of energy. Outmoded regulations prevent energy recycling innovators from picking up US$40-60 billion per year of 'US$20 bills' that are lying on the ground. Policymakers have a golden opportunity; by modernizing the regulations and regulatory approach and removing barriers to efficiency, they can unleash a flood of recycled energy that will pay US industry for its waste energy, reduce dependence on fossil fuel use, cut pollution, and cut future electric prices by 40 percent. Recycled energy is the missing link to sensible energy policy. ■

[1] EPRI, The Electricity Sector Framework for the Future, August 25, 2003, http://www.epri.com/corporate/esff/viewpdf.asp
[2] Casten, T & Collins, M, Cogeneration and On-Site Power Production, Optimizing Future Heat and Power Generation, Nov-Dec 2002
[3] Recycled Energy: An Untapped Resource, Casten and Collins, April 2002. Available at www.primaryenergy.com